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Challenges and opportunities for semiconductor and electronic design automation industry in post-Covid-19 years

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Abstract. The coronavirus pandemic found the semiconductor industry and the chip production supply chain ecosystem unprepared. Companies and main actors in the sector could not read the signs. The decision-makers suffered to deal with the challenges in time and take the right actions. The bullwhip effect caused by the COVID-19 destabilized the operations and some of the experts say that these problems might last and on the other side, this might open doors to innovative solutions that might change the game. The global shutdowns, the misread of the demand for electronics, underestimating customers' demand for the automotive sector, and the Internet of Things in general, were some of the main problems causing chaos in the industry. The paper studies the state-of-the-art and the solutions offered by the semiconductor industry and by the initiatives that Europe, the USA, and especially China, took to make companies and their countries take the most out of this situation.

1. Introduction

One of the problems caused by the COVID-19 long shutdown was the “chip shortage” problem. From a business and strategy point of view, this anomaly had a significant impact on businesses related closely to the semiconductor industry and chip production ecosystem. Automakers were the ones most impacted by losing billions of dollars in earnings during 2020 [1]. The automotive industry could not have in time the necessary supply to deliver its main products. The chip shortage caused a ripple effect for the entire network.

Electronic chips are used in everything, in electronic systems and electronic cars. This shortage is one of the first big problems for the Electric Vehicle industry [1]. Due to the high demand for electronic-based products during this period, the demand for semiconductor chips increased more and more. Foundries and chip designers found themselves under pressure to keep up with filling the needs in a short time in a middle of a crisis.

Companies are still trying to figure out how to recover from the lack of supply and how to fulfill the demand. Managers and decision-makers are divided when it comes to how all this will impact the current balances in the industry and how long will be needed to overcome the barriers and challenges. The EDA providers, once offering online and free options products tended during the pandemic to change the approach with pressure on users for payments with different schemes. Their revenues increased during the pandemic time [2]. Some companies planned to invest in opening new plants to



cover the needs of the production, others are still trying to develop monitoring and controlling activities to keep in control the distribution of chips and the demands.

Different causes contributed to the expansion of this situation. On the other hand, different analysts suggest that this situation might change the game for the electronic-supported industries.

1.1 Global shutdowns

Due to global shutdowns and people staying at home, consumers increased their demand for electronic-based products. Companies in charge of producing those electronics increased their request for more semiconductor chips from the suppliers to fulfill their needs. Due to restrictions, some plants were closed, and the production of some parts was stopped. This increase in demand overwhelmed the foundries and manufacturers [1].

1.2 The demand for electronics increased

According to Gartner, the sale of PCs rose to 275 million units during the difficult year of 2020 [3]. Despite the Apple increase of orders for its product and especially the iPhone, still, the company said it did not have enough supply for its new electronic products [3].

Manufacturers of consumer electronics and automakers pushed the chip designers to provide them with a bigger amount of complex chips. These companies caused foundries an extra wave of demands putting them in a difficult position to fulfill the request [6]. A shortage of chips was the start of 'chaos' for companies working directly with semiconductor chips in their electronic products as shown in Figure 1.

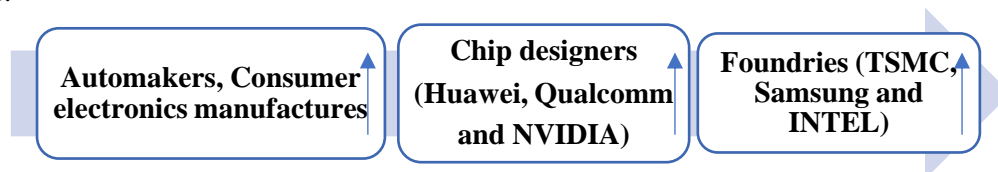


Figure 1. Increase of demand for semiconductor chips.

1.3 Automakers underestimated customers' demand for cars and decreased production

The chip shortage situation exposed the priority of automakers in the foundries' demand plan fulfillment. Consumer Electronics and the Internet of Things (IoT) are the "volume" companies demanding the biggest amount of semiconductor chips. Automakers discovered that they were after these companies and that is why the foundries were focused on the production of consumer electronics semiconductor chips. On the other hand, there was an increase in demand for automotive cars and the lack of chips caused problems. In 2020, only 3% of Taiwan Semiconductor Manufacturing Company's (TSMC) sales were from automotive chips, compared to 48% for smartphones [3].

The global market of green cars has already been struggling with technological challenges required to keep up with the future of the automotive industry and mobility and with the initiatives to regulate the market through regulators. The automotive industry requires electronic chips more than ever and more than any other industry pushed by the latest technological advancements. In 2017, electronics made up more than 40% of the automotive total cost [3]. Despite the low sales of these cars and mobility options, the automotive industry is one of the near future industries that will change the game. The advanced functionalities of these cars will request more advances and personalized chips. Manufacturers and companies are under continuous pressure to lead the high demand for these chips in time. There is an imbalance of supply and demand causing shortage and latency in the process [4]. COVID-19's unpredictable situation enhanced further the supply and demand problems between customers and chip manufacturers.

Volkswagen revealed that was difficult for the company to build 100 000 cars due to the 2020 chip shortage, Tesla was also affected by this situation declaring "having 'some of the most difficult supply challenges we've ever experienced'". Jaguar Land Rover and Daimler companies took some measures to reschedule production activities in their plants due to lack of chips [5].

2. Reaction to Chip Shortage

According to Goldman Sachs, this problem might last till the end of 2021 and according to Acer, this crisis might last until 2022/2023 [7][8].

There are different approaches to deal with crises. Companies can move production in-house or can invest in the new expansion to deal with the increased demand. Investing in in-house production might not be the solution since the problem comes from the lack of inputs and not from the process of manufacturing. Some semiconductor manufacturers have announced an investment in new foundries and factories hoping to increase the supply. These factories might take two years to build and during this time a lot of things might change, and the chip shortage problem might ease [4].

Fast reaction without a proper analysis might unbalance the industry and especially in companies operating in the value chain processes. Semiconductor leaders should manage this situation properly otherwise they might create a similar situation soon. Some suggest that the market requires a controller to monitor the distribution of the chips based on the company's needs and ensure that the chip allocation will allow all companies and chip customers to survive and grow. Companies should focus more on developing and cultivating strong and stable relations with their co-operators, suppliers, partners, competitors, and even their personnel. Customers of chips should choose smart and gain trust to work with suppliers that know and can align with their business's needs [9][10].

Tan Hock, CEO of Broadcom said that their company will follow a strategy to ensure that all their customers get the product, despite some latencies [4]. Proper distribution of chips and prioritizing demands might be a good solution to problems similar to this. TSMC announced that they will focus on fulfilling demands from the automotive industry, one of the industries that had the biggest damages during this year [4]. Tower Semiconductor Ltd. declared that they could speed up the chip production process and sort their lines in a way that the customers that have top priority to be supplied with the required products [11].

2.1. *The Electronic Design Automation industry reaction to COVID-19*

Despite problems in the semiconductor ecosystem caused due to COVID-19, the Electronic Design Automation (EDA) sector is experiencing increased revenues and profits. In general, the software development industry managed to grow its profit during this difficult period and EDA did not stay behind. According to Walden C. Rhines, CEO of Mentor Graphics, now known as Siemens EDA, he believes that one of the reasons why the industry received increased revenues, was due to long-term and stable investments in research during the years [2].

An interesting trend to be seen is the increased demand for EDA tools during long shutdowns and at the same time the rise for cloud EDA. The market of EDA cloud is expected to grow and to receive special attention during this time [12][13]. Taking advantage of the cloud can help companies to provide the tools to designers 24/7 and at lower costs [13]. Another reason why U.S EDA companies seem to have secure and sustainable growth is that due to this trade war between China and the USA, the USA government is investing in a system-level design that will help produce advanced and high level of security chips [14].

2.2. *The reaction of countries to COVID-19 chip shortage*

Leader countries in high technologies are trying to build policies on how to be independent to chip manufacturers that are mainly covered by South Korea and Taiwan, around 75% of the chip production according to US-based semiconductor industry association [15]. USA government and European politicians desire those chips to be made and developed locally, some of them fear the reunion of China with Taiwan, especially since the high-tech chips coming from China increase [15] [16].

Amid chip shortage and fears that China is investing in being independent and leading the industry, the US government released a plan to boost the production and development of the semiconductor industry further and propose an investment of 50 billion dollars on infrastructure. This technological war between the two countries has made governments of both countries develop plans to increase their

presence and to develop advanced tools to make their nations independent and secure. Security concerns that come with advanced technologies are one of the reasons why Biden is taking this seriously [17].

The third entering this war for the chips is the European Union. Angela Merkel, the German Chancellor, declared that Germany in cooperation with European companies is investing in the chip industry [17]. There are around 22 European countries that have joined forces to work together on developing a local semiconductor ecosystem, according to Thierry Breton, the chief of European industry [18]. The EU is focusing on local production of chips and becoming more independent from the USA and Taiwan and other east countries [19]. There is still no clear how things will go but different scenarios exist and one of them is the rise of China as the leading country in the industry. The following sections give an overview of the situation in China regarding semiconductor investments and development plans.

2.3. *The rise of China in the semiconductor ecosystem*

Trade and technological war between the USA and China uncovered some of the weaknesses of China's semiconductor ecosystem, especially in the electronic design automation industry subsector. The government and the Chinese companies started to think and look for local opportunities and policies to support, use and grow their presence in the industry [20].

The chip shortage advanced the current problem since China is rising demand for electric and new advanced cars and the lack of know-how, manufacturers, and the tension in the region might be a big problem for it [21]. On the other hand, these problems go beyond the COVID-19 chip problem. (Yuan Chengyin, general manager of the National New Energy Vehicle Technology Innovation Center). According to him, China will be more vulnerable to global impact and dynamics in the chip supply chain and ecosystem. Investing and growing in this area seems like a challenge for China but at the same time, a new country that will invest in technological know-how in this area might cause distort the current stable market of the semiconductor ecosystem [20] [21].

In the last years, the Chinese government, being aware of entering too late in the market, is investing in the semiconductor sector by developing policies, realizing concrete plans on chip production, and supporting new initiatives in the business field [22]. The history of China during the years and the Chinese government policies to support the advancements in high technologies in the nation are listed in Table 1 (Adopted by [20]).

Table 1. Chinese government policies to support the advancements in high technologies in periods.

Years	Event
1990 to 2000	State planning focus
1991	Development of the Eighth Five-Year Plan (FYP) document where the “the main task” of the state was the industry development.
2000 to 2013	First China-based foundries. Semiconductor Manufacturing International Corporation (SMIC)
2014	- Release of the National Integrated Circuit Industry Development Guidelines - National IC Investment Fund establishment
2015	The Made in China 2025 (MIC2025)4 initiative.
2018	Section 301 report by the U.S. Trade Representative (USTR) on China's trade policies in March 2018, the start of the trade war between China and the USA. Chinese officials increased their focus on making China less dependent on companies currently leading the market and preparing the domestic market for its resources and local supply chain development.

The case of building a chip production ecosystem in China will require a lot of knowledge and capital, mature technology, and a sustainable business ecosystem to enhance development. New

companies in China must deal with established companies that already lead the market and have an advantage in terms of covering most of the market, economies of scale, brand recognition, and patent quality [23].

On the other hand, the idea of everything developed and made by China seems like an “aspiration” difficult to be achieved, especially since most of the companies operating in China desire to go beyond the domestic market towards global markets. Table 2 (Adopted by [20]) shows the current situation in China of the companies and market share it covers.

Table 2. Current situation in China of the companies and market share it covers.

Semiconductor industry subsectors	China’s current place
Foundries	2 companies (SMIC and Hua Hong)
IDMs (integrated device manufacturers)	0 companies
Semiconductor Design companies	China is the second after the USA, surpassing Taiwan.
Electronic design automation industry	China is far beyond when it comes to EDA tools developers. It is the weakest point of the semiconductor supply chain in China together with the manufacturing materials and supplies
OSAT (outsourced assembly and test)	Tongfu Microelectronics, JCET, and Tianshui Huatian Technology Chinese companies trying to gain more share in the market which is led by the Taiwan firms.

Currently, China is encouraging foreign companies to invest and bring their technologies, talents, and research centers to China. There are specific policies, such as tax, tariff, and materials offered by the Chinese government for the following years to support the development in this area. On the other side, many members of the USA Congress and policymakers are concerned about the potential of China to take the lead in the semiconductor industry based on their good attraction policies [20].

3. Conclusions

The chip shortage problem exposed the weaknesses in the chip production ecosystem and chip supply chain. More than lack of materials, or a shutdown caused by COVID-19, the problem was a lack of proper decision making. Leaders of companies failed to read properly the demands, trends and to allocate the resources according to the needs. This led to an unstable situation that will require some years to come back to normality. On the other hand, it seems that it opened new possibilities and opportunities to change the game. New companies might take the lead. EU, the USA, and China are fighting to shift the production of chips locally and to control the market. It is early to predict where this is going but the industry might experience some fundamental changes. The currently established organizations might have to restructure the market and develop new strategies to keep their place in the industry.

Additionally, academia in the EU and USA should increase the courses and studies in Computer-aided design of electronic chips to avoid the loss of know-how in this area and to be ready for further challenges.

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